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PERIODIC LAW OF ATOMIC NUCLEI: CHEMICAL ANALOGS OF THE ELEMENTS IN THE PERIODIC SYSTEM OF ATOMIC NUCLEI

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/Figures and table are appended./

(Russian editor's note: The material upon which A.P. Znoyko's article, "The Periodic Law of Atomic Nuclei," was based was presented by the author in the Academy of Sciences USSR in July 1947.)

The periodic law of the atomic nuclei, which was stated clearly in our previously developed (1) system of isotopes, permits a positive approach to the discussion of chemical analogs of the elements of D.I. Mendeleyev's system on the basis of nuclear structure. The periodicity was based upon a characteristic quantity, the specific nuclear charge Z/A for nuclei of the "main" isotopes /"Main" isotopes are those that are most abundant/. The periods and structures of nuclei in the system of elements were shown by the curve of Figure 3 in our first report (1). The existence of four complete physical periods (not counting the zero period and the incomplete fifth period), which determine the appearance of corresponding analogs, was demonstrated. Above this figure, there were shown the boundaries of the long physical periods of the nuclei, which were terminated by the chemical analogs calcium, strontium, barium, and radium, and contain, respectively, 18, 18, 18, and 32 elements. The separate periods consist of atomic nuclei which are characterized by one definite type of structure, or else the period is divided into a number of sections differing in the type of nuclear structure. In the present article the curve of Figure 1, which was constructed for nuclei of even and odd Z's of the "main" isotopes, illustrates the development of the elementary cycles of the nucleus with respect to the separate physical periods in the same coordinate axes Z/A - Z. The over-all drop in specific charge is clearly seen. Within the limits of an individual period, a general stabilization or a general drop in specific charge takes place for each structure. Within the limits of each type of nuclear structure, the periodically repeated rise and fall of the quantity Z/A from each even to each odd element is shown.

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The graphs in Figures 1 and 2 show the boundaries of the periods and the beginning and end of each type of nuclear structure and serve as a basis for the construction of a periodic system of elements in the customary plane representation. The physical periods of atomic nuclei in the system of elements and the types of nuclear structure are shown in Table 1. Isotopic number and specific nuclear charge of the "main" isotopes are given in addition to the symbol.

For the lanthanum elements, specific charges were calculated according to the average isotopic mass, a procedure which, given several abundant isotopes, depicts the center of gravity of the system in the best fashion.

The second period Sc, Sr, and the third period Y, Ba contain two types of nuclear structures. As seen in Table 1, the quantity Z/A increases slowly for each element (for even and odd Z's individually) on the section of the second period from Sc to Zn. Stabilization (increase) of the specific charge on this section is explained by the fact that the mass of the nuclei increases from element to element because of the formation of alpha-bonds, while the number of free neutrons remains constant ($j_{even} = 4$; $j_{odd} = 5$). After a certain stabilization of the specific charge has been attained, the nuclei can no longer be constructed by this principle, i.e., by the addition of new alpha-bonds for the given $j = 4$. A new section Ga - Sr of this period appears, on which the specific charge of the main or corresponding isotopes decreases for all nuclei of even and odd Z's. The isotopic number of the corresponding isotopic nuclei increases to some new value, further proof of the previously described method of construction of nuclei because of the formation of alpha-bonds for $j =$ const. The third period, Y - Ba, has at first a stabilization (increase) of the specific nuclear charge at the transition elements, and then a decrease in the quantity Z/A from In to Ba.

Thus, the repeated rise and then fall of the specific charges of the main isotopic nuclei on the corresponding sections of the system and the changing method of nuclear construction connected with it permit us to speak of periods of atomic nuclei, ending with Ca, Sr, and Ba. The fourth period begins with La, but does not continue into the second structure section already described. A new section of lanthanum elements emerges. The lanthanides could be placed in one square with respect to nuclear structure and Clark number (relative abundance). After the lanthanum section, we have formation of structure according to the principle described, with the alkali-earth metal Ra ending the fourth period. Then we have the fifth period, beginning with As and ending with Ci.

The connection of the separate structural sections of the nucleus with the filling of the inner electronic envelope in atoms of the transition elements is quite apparent. This correspondence cannot be due to chance alone, and should be studied to establish general laws for the atom as a whole.

The general laws of the periodic system of the nucleus are closely linked with the known laws governing the relative abundance of elements in nature. The periodic law permits us to point out a number of elements, which, by their position in the periods, can be distinguished by their stability and structure. These elements must include Be and also Ti and Zn as elements of even Z's of the beginning and end of the first structure of the second period. It is natural that the elements Ge, Sn, and Pb as the first even Z's of the new structure (see Table 1) should be distinguished by their nuclear stability. From these considerations, it is possible to pick out Zr or, for example, Th, as beginning a new structure.

It is possible that the structural periods of nuclei are not an exact reflection of the chemical periods of D.I. Mendeleyev. In the future, the nature of the underlying similarity, which is connected with complex laws still not completely discovered, should be revealed and clarified.

Having noted the apparent separation of the system of elements into four nuclear periods and the separation of elements into the corresponding types of analogs, we now consider the development of the electronic structures in the periods. The electronic structure of elements of the first nuclear period up to Ca develops normally. After the helium shell, the electronic shell L from Li to Ne is filled by eight electrons, and then the M shell is also filled up to Ar. In K and Ca, the next two electrons fill the M shell in the 4s-term. After Ca, however, instead of filling the N shell by electrons of the 4p-term in the following elements, in the interval where the nuclear charge is increased by ten units, the inner shell M is filled by ten electrons in the 3d-term. Only after the electron shell M has been filled by up to 18 electrons does the electronic structure develop as previously (from Zn, the analog of Mg) and do analogs of chemical periods I and II appear. After eight elements, the structure of Sr is formed, after which the filling of the inner N shell in the 4s-term is repeated.

Comparison of the energies of electrons in the 3d- and 4p-terms shows the changes in the atomic system which govern the filling of the inner electron shell M after Ca. Figure 2 shows the variation in electron energy according to the s, p, d, f terms of the electronic shells M, N, O, P.

We see that an electron which fills the atomic structures after Ca in the 3d-term has considerably less energy e. Designating the difference in energy of electrons in the terms 4p and 4s as E and the difference in energies of electrons of 4p and 3s as e, we see that E is greater than e. Thus, after Ca, an electron having smaller potential energy is compensated successively by the increase of one unit in the nuclear charge. In this case, the increase in nuclear charge by one unit yields an energy state of the nucleus that cannot compensate the energy of the 4p-electron. The electrons fill the 3d-term, which after ten elements stabilizes the system.

Considering the nuclear periods of Sr, Ba, Ra, we see that after each period the atomic system enters into a state where the increase in the nuclear charge by a unit will not permit the electronic structure to continue to develop according to type I and II chemical periods. The system of elements develops in the direction of the radioactive alpha-emitters, and this connects the structure of electronic shells with the varying stability of the nucleus.

Thus we conclude that in the system of elements the structure of the electronic shells of atoms is connected with the variation in structure and the charge density Z/A of complex nuclei. This variation in charge density must depend not only upon the number of free neutrons j, but also upon the mutual distribution of particles in complex nuclei as observed in the case of the nuclear lanthanide arrangement which is accompanied by the filling of the electronic 4f-term.

BIBLIOGRAPHY

1. A.P. Znoyko, DAN, 68, No 5 (1949).

2. A. Ye. Fersman, DAN, A, No 11, 261 (1932).

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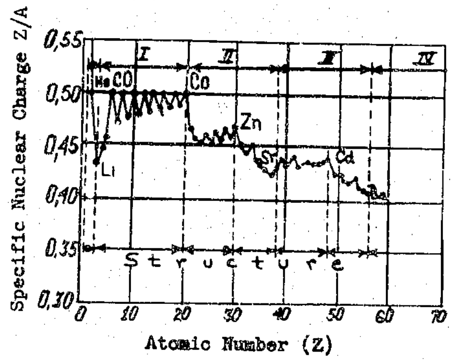

Figure 1. Periodic Law of the Atomic Nucleus (Elementary Cycles)

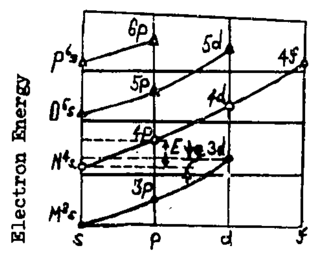

Figure 2. Variation in Energy of an Electron With Terms s, p, d, f

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Chemical Analogs of Elements of the Periodic System of Atomic Nuclei

Physical Periods of Nuclei	Structure of Nuclei I									
O							H	He		
I	1 0.429 Li	1 0.444 Be	1 0.454 B	0 0.5 C	1 0.467 N	0 0.5 O	1 0.474 F	0 0.5 Ne		
	1 0.479 Na	0 0.5 Mg	1 0.481 Al	0 0.5 Si	1 0.484 P	0 0.5 S	1 0.486 Cl	0 0.5 Ar	1 0.488 K	0 0.5 Ca
II			7 0.450 Ga	6 0.457 Ge 10 0.433	9 0.449 As	8 0.447 Se 12 0.425	11 0.432 r	10 0.439 Kr 14 0.419	13 0.425 Rb	12 0.432 [illegible]
III			17 0.425 In 18 0.424 20 0.416	16 0.431 Sn 18 0.424 20 0.416	19 0.421 Sb	18 0.426 Te 20 0.419 22 0.412	21 0.417 J	20 0.421 Xe 22 0.415 24 0.407	23 0.413 Cs	22 0.417 Ba 24 0.411 26 0.406
IV			43 0.398 Tl	42 0.397 Pb 44 0.394	43 0.397 Bi	44 0.396 Po 46 0.393	At	48 0.391 Rn 50 0.387	49 0.309 Fr	50 0.389 Ra 52 0.386
V										

Chemical Analogs of Elements of the Periodic System of Atomic Nuclei (Contd)

Physical Periods of Nuclei	Structure of Nuclei II									
O										
I										
II	3 0.466 Sc	4 0.458 Ti	5 0.451 V	4 0.462 Cr	5 0.455 Mn	4 0.465 Fe	5 0.457 Co	4 0.468 Ni	5 0.460 Cu	4 0.469 Zn
III	11 0.439 Y	12 0.435 Zr 14 0.426	11 0.441 Nb	12 0.437 Mo 14 0.429	13 0.434 Tc	12 0.44 Ru 14 0.431	13 0.437 Rh	12 0.442 Pd 14 0.433	13 0.439 Ag	12 0.444 Cd 14 0.436
IV	25 0.405 La	34 0.405 Hf 36 0.40	35 0.403 Ta	34 0.406 W 38 0.398	37 0.400 Re	36 0.404 Os 38 0.40 40 0.398	39 0.398 Ir	38 0.401 Pt 40 0.398	39 0.400 Au	38 0.403 Hg 40 0.399
V	49 0.392 Ac									

Physical Periods of Nuclei	Structure of Nuclei III													
IV	0.407 Ce	0.419 Pr	0.416 Nd	Cy	0.412 Sm	0.412 Eu	0.407 Gd	0.408 Tb	0.407 Dy	0.410 Ho	0.406 Er	0.407 Tu	0.404 Yb	0.406 Cp
V	52 0.387 Th	49 0.394 Pa	54 0.386 U	51 0.389 Np	51 0.393 Pu	51 0.394 Am	50 0.397 Cm							

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